# 5.0 LINKAGE ANALYSIS AND TMDLs (LOAD CAPACITY)

As stated by the USEPA (1999b), the linkage analysis is an essential component of the development of a TMDL. A link needs to be established between predicted sediment loads and the numeric target(s) chosen to measure the attainment of beneficial uses. This linkage allows the assimilative capacity for sediment loading to be determined for the impaired body of water.

The relationship or link between the selected numeric target(s) and the predicted sediment loads can be determined using a combination of monitoring data, analytical tools (including models), and best professional judgment (USEPA 1999b). Ideally, a long-term monitoring data set with different flow regimes and sediment loads would be available for the body of water in order to determine the load capacity under various hydrological regimes. Once the load capacity is determined, the amount of sediment loading reduction needed to meet the selected numeric target(s)/TMDL is quantified.

**Big Bear Lake**

As discussed in Section 3 – Numeric Targets, the USEPA has acknowledged the difficulties in establishing TMDLs for sediment. Spatial, temporal and climatic variability in sediment yields makes it difficult to define "average" sediment mass loads that can be related to beneficial use impacts or to specific source contributions. As reflected in the Source Assessment Section (Section 4), it is also difficult to differentiate between erosion and sedimentation that occurs naturally and that resulting from disturbed areas, particularly where, as here, data are extremely limited. The USEPA has identified sediment TMDL approaches other than mass loading, and the proposed numeric targets reflect this flexibility.

The proposed TMDL for Big Bear Lake (Table 5-1) is the same as the proposed sediment load numeric target. The intent is to assure that anthropogenic sources are controlled to the maximum extent practicable, and wasteload and load allocations are proposed accordingly (see Section 6.0). An extended compliance schedule (as soon as possible but no later than 2020) is proposed to allow the development and implementation of appropriate control or sediment trading[32] measures, and, perhaps more importantly, to allow the collection of much-needed, relevant data to enable accurate assessment of source contributions and their effects on the lake. The numeric target and TMDL will be reviewed and revised as necessary based on additional data collection required by the proposed implementation plan (Section 9).

The other numeric target proposed for Big Bear Lake is a 5% increase in lake capacity, to be achieved no later than ten years from the effective date of the TMDL. This target is not used as the basis for establishing allocations. It is intended to provide more evident and direct control over the loss of lake capacity due to sedimentation and resultant impairment of the municipal, biological and recreational beneficial uses of the lake. As discussed in Section 3, this target is tied to a requirement in the proposed implementation plan for the development and implementation of a lake management plan that would integrate sediment control and management with programs to restore and protect the beneficial uses of the lake, including those related to the lake's biological and recreational resources. The lake is man-made, and its continued existence relies on the efforts of stakeholders to maintain and protect it. The identification and implementation of an appropriate lake management plan by the stakeholders is

[32] Where compliance with the proposed wasteload or load allocations is infeasible, implementation of measures (e.g., in-lake dredging) to mitigate excess sediment contributions can be implemented.

the sensible and practical approach to assure that the water quality problems affecting the lake (including nutrients as well as sediment) are addressed in coordinated fashion, and that beneficial uses are restored and protected.

This lake capacity target reflects the difficulty in predicting the linkage between erosion in the watershed (due to hillslope processes, channel erosion, etc.) and in-lake conditions because although erosional processes occur in the watershed, sediment might not be transported immediately to stream channels and thence the lake. As already noted, seasonal and annual variations in the delivery of sediment to stream channels also exist. In the case of Big Bear Lake, the long-term sediment load to the lake is more important than a detailed analysis of in-stream storage and transport. Comparison of the calculated load resulting from natural background sources and the estimated loads from all sources in the watershed for 1990-2003 (Table 4-2) indicates that the majority of the sediment entering Big Bear Lake arises from natural sources. The proposed lake capacity target takes these circumstances into account and requires stakeholders to implement a coordinated program that is expected to include both source control measures and in-lake remediation activities.

The proposed TMDL shown in Table 5-1 uses an "inferred linkage" based on comparison of loads from natural background (e.g., forest land uses) with existing loads from the watershed. The assumption is made that some loading reduction in the watershed combined with sediment removal in the lake will result in the attainment and maintenance of beneficial uses. Reducing sediment loads to natural background conditions may still result in unacceptable sediment loads to the lake, but it is not feasible to reduce sediment loads to the lake completely since erosion is a natural process. The proposed TMDL target, 12,000 tons of sediment per year, expressed as a 10-year running average, reflects the assumption that BMPs will be effective when fully implemented (and assuming a 10% margin of safety-see Section 8.0).

BMPs are in place in the ski areas (e.g., culverting, over side drains, cross ditching, mulching, grass growing and irrigation, protective matting, silt collection basins and debris rakes, flow channels and runoff filtering) (Klouzer 2004). The effectiveness of each of these BMPs is not known at this time. Future monitoring will allow for better quantification of the total effectiveness of implemented BMPs and the sediment load that these BMPs already control. Load allocations can be adjusted based on this new information. The USFS is responsible for controlling NPS runoff from their lands. The USFS has signed a Management Agency Agreement (MAA) with the SWRCB to manage NPS pollution from their lands and has a manual for implementing BMPs and assessing their effectiveness on USFS lands (USDA 2000). No information was received on BMPs implemented by the USFS. As monitoring is conducted in the future, this information can also be quantified. The City and County both implement BMPs in accordance with the MS4 permit. Again, with future monitoring, the effectiveness of each BMP can be elucidated and wasteload allocations can be adjusted based on this information.

**Rathbun Creek**

Many of the difficulties in identifying the specific linkage between sediment loading, numeric targets and beneficial use impacts for Big Bear Lake, discussed above, pertain also to Rathbun Creek, e.g., lack of data, spatial and temporal variability in erosion and sediment transport. However, in the case of Rathbun Creek, the use of the proposed benthic macroinvertebrate target can aid in the determination of acceptable sediment loads. Using both the IBI and the O/E model will allow a direct linkage to be made between levels of sediment loading and ecosystem health. Currently, the only comparison that can be made is to the benthic macroinvertebrate study conducted in 2002, when conditions were representative of a degraded system. Future survey

results will be compared to the year 2002, and changes in the macroinvertebrate community can be detailed and related to sediment data.

As with the Big Bear Lake TMDL, the Rathbun Creek TMDL also relies on an "inferred linkage" based on comparison of loads from natural background (forest land uses) with existing loads from the watershed. An assumption is that the reduction in sediment loading from the watershed to natural background loads will achieve an improvement in benthic macroinvertebrate community health and beneficial uses will be attained and maintained. The proposed TMDL target, 1900 tons of sediment per year, expressed as a 10-year running average, reflects the assumption that BMPs will be effective when fully implemented (and assuming a 10% margin of safety –see Section 8.0).

As discussed above for Big Bear Lake, additional studies are needed to evaluate the effectiveness of the BMPs implemented by various stakeholders.

## 5.1 Proposed TMDLs

Tables 5-1 and 5-2 summarize the proposed sediment TMDLs for Big Bear Lake and Rathbun Creek necessary to achieve the final numeric targets. Included are the proposed allowable loads from all external sources. The TMDL, WLAs and LAs are based on the average of sediment loads from the 14-year period, 1990-2003, and are consistent with the proposed numeric targets discussed in Section 3. Existing sediment loads are also based on the average of sediment loads from this 14-year period (Table 4-3). This 14-year period incorporates loads from wet, average, and dry hydrological periods. The proposed TMDLs are based on a 10-year running average, to account for the inherent seasonal and annual variations in sediment loads. The allowable loads for each source are compared to the existing average load for each source to determine the reductions that will be required to meet the recommended numeric targets.

**Table 5-1. Sediment TMDL to achieve the sediment numeric target (12,000 tons/year expressed as a 10-yr running average) for Big Bear Lake (to be met as soon as possible, but no later than 2020) (all numbers in tons/year)**

| | Sediment | Existing Sediment Load | % Reduction |
|---|---|---|---|
| External loading | 12,000 | 12,946 | 7 |
| **TMDL** | **12,000** | 12,946 | 7 |

**Table 5-2. Sediment TMDL to achieve the sediment numeric target (1900 tons/year expressed as a 10-yr running average) for Rathbun Creek (to be met as soon as possible, but no later than 2020) (all numbers in tons/yr)**

| | Sediment | Existing Sediment Load | % Reduction |
|---|---|---|---|
| External loading | 1900 | 2324 | 18 |
| **TMDL** | **1900** | 2324 | 18 |

The next section describes the allocation of these proposed TMDLs to different sources.

# 6.0 TMDL ALLOCATIONS

As discussed in Section 4.0, sediment inputs to Big Bear Lake come from both point source and nonpoint source discharges. The TMDLs must account for both types of inputs, as well as a margin of safety. This is expressed as follows:

TMDL = ΣWLA + ΣLA + MOS

where:

WLA = wasteload allocations for point source discharges
LA = load allocations for nonpoint source discharges
MOS = Margin of Safety

An explicit MOS of 10% of the TMDLs is proposed for each of the TMDLs (see Section 8.0).

Point source discharges of sediments to Big Bear Lake include urban storm and non-stormwater runoff (MS4 permitted dischargers and Caltrans).

Nonpoint source discharges of sediments include forest and resort runoff.

The proposed allocations are not affected by future growth in the watershed because the watershed is already close to its build-out capacity.

The allocations for the all the land use based sources are considered together as follows:

Urban WLA + Forest LA + Resort LA = TMDL – MOS

Proposed WLAs and LAs to achieve the TMDLs for Big Bear Lake and Rathbun Creek are shown in Tables 6-1 and 6-2, respectively. The percent reduction in sediment load from each source that would be required to comply with the allocation is also shown.

**Table 6-1. Proposed TMDL, wasteload and load allocations for Big Bear Lake (to be achieved as soon as possible, but no later than 2020)***

| | | Sediment load allocation (tons/yr) | Existing sediment load (tons/yr) | Reduction (%) |
|---|---|---|---|---|
| **TMDL** | | **12,000** | **12,946** | **7** |
| **WLA** | | **3100** | 3532 | 12 |
| | Urban | 3100 | 3532 | **12** |
| **LA** | | **7700** | 9413 | 18 |
| | Forest | 7100 | 8735 | **19** |
| | Resort | 600 | 678 | **12** |
| **MOS** | | **1200** | | |

*Specified as a 10-yr running average based on a calendar year (January 1- December 31)

**Table 6-2. Proposed TMDL, wasteload and load allocations for Rathbun Creek (to be achieved as soon as possible, but no later than 2020)***

| | | Sediment load allocation (tons/yr) | Existing Sediment load (tons/yr) | Reduction (%) |
|---|---|---|---|---|
| **TMDL** | | **1900** | **2,324** | **18** |
| **WLA** | | **650** | 810 | 20 |
| | Urban | 650 | 810 | **20** |
| **LA** | | **1060** | 1513 | 30 |
| | Forest | 730 | 1102 | **34** |
| | Resort | 330 | 411 | **20** |
| **MOS** | | **190** | | |

*Specified as a 10-yr running average based on a WY

The following describes the approach used to determine the LAs and WLAs for each of these sediment sources.

First, staff utilized the HSPF model results from Hydmet, Inc. (2004) to determine current sediment loading from each source (Tables 4-3 and 4-4). Staff then determined the reductions required from all sources in order to meet the proposed TMDLs (Tables 5-1 and 5-2). The requisite reductions were then allocated among the sources, based, in part, on consideration of information concerning present BMP implementation. The ski resorts and the City of Big Bear Lake each submitted letters that contained a description of BMPs that they have implemented in the watershed to control sediment loads from their jurisdictions; however, there was no information provided as to the effectiveness of these BMPs (Klouzer 2004; Perry 2004). No information was received on BMPs implemented by the USFS. A report produced by RBF Consulting for the Orange County Stormwater Program in 2003 summarized BMP effectiveness and provided maintenance and cost estimates for a variety of BMPs implemented by different agencies. This report was reviewed to determine reasonable and feasible percent load reductions for sediment (i.e., TSS) (RBF 2003). An average percent removal efficiency of 70% for TSS was thought to be acceptable based on the reported removal efficiencies. In light of this information, reductions of up to 34% are proposed to meet these TMDLs and are considered reasonable. Given that the city/ski resorts have implemented some BMPs, for the Big Bear Lake TMDL, lower reduction percentages were assumed for urban and resort (12% each) than for forest (19%). These percentages were applied to the HSPF simulated existing sediment loads to calculate the sediment load allocations for each source. Similarly, lower sediment reduction percentages were assumed for urban and resort for the Rathbun Creek TMDL (20% each), than for forest (34%). Again, these percentages were applied to the simulated existing loads from each source to calculate their respective allocations. The USFS is the largest landowner in the watershed and thereby the largest contributor of sediment. Reduction of this load is thus particularly important.

Since they are based on HSPF results for the period 1990-2003, the proposed TMDLs, WLAs and LAs take into consideration the cumulative effect of the watershed hydrological conditions during wet, average and dry years. The allocations shown in Tables 6-1 and 6-2 are proposed to apply as 10-yr running averages to account for variations in hydrological conditions. The 10-year running average means that at the end of 10 years after the TMDLs take effect, an average will be calculated using the first ten years of annual averages. Thereafter, the ten year running average will be calculated annually, using the annual averages of that year and the preceding nine years. Loads from each source over the calendar year (CY) (January 1-December 31) for the 10-yr

running average shall not exceed the allocations specified in Tables 6-1 and 6-2. Staff proposes that the allocations be achieved as soon as possible, but no later than 2020. The proposed implementation plan includes the requirement for the collection of additional data to provide interim evaluations of the effectiveness of the BMPs implemented, and to enable the calibration of the watershed model for sediment under all hydrologic conditions.

In the event of catastrophic events, such as a wildfire or massive landslide, the USFS should implement BMPs, as outlined in the USFS' BMP manual for Southern California (USDA 2000) in a timely and aggressive fashion so as to prevent or at least minimize resultant erosion and sedimentation. The MAA between the SWRCB and the USFS calls for the USFS to implement BMPs to the extent feasible. With respect to meeting the proposed sediment load allocations and TMDLs, staff recognizes that in the event of fires, mass wasting or other natural uncontrollable phenomena, the TMDLs and sediment load allocations are likely not to be met. In these instances, the proposed capacity target for Big Bear Lake and the benthic macroinvertebrate target for Rathbun Creek will be the drivers for control and remediation actions to protect beneficial uses.

## 7.0 SEASONAL VARIATION AND CRITICAL CONDITIONS

TMDLs must include consideration of seasonal factors. The difficulties in establishing TMDLs for sediment because of seasonal/climatic variability in loading have already been noted (Section 3). In Big Bear Lake and Rathbun Creek, external loading of sediment is greatest during the winter and spring months due to rainfall and snowmelt. To address this variability, annual average sediment loads from each significant source were simulated with the HSPF model for a 14-year period (1990-2003), which incorporates all types of seasonal/hydrological conditions. These results are the basis of the proposed targets, TMDLs, WLAs and LAs. In addition, the numeric sediment targets, TMDLs, WLAs and LAs are proposed as 10-year running averages to take annual variability into account. The proposed lake capacity target requires improvement in lake capacity over time, despite seasonal, climatic or other variations in sediment loading.

TMDLs must also include consideration of critical conditions to ensure that even under the worst water quality conditions, water quality standards can still be met through implementation of the TMDL. Erosion and sediment deposition can exert both immediate and long-term adverse impacts on beneficial uses. To the extent that erosion and sedimentation in Big Bear Lake and Rathun Creek are associated with storm or other events that result in the removal or covering of spawning substrate for fish or other organisms, there may be immediate adverse effects on aquatic biota during these conditions. Reasonably feasible control measures must be implemented to address such inputs. Compliance with the proposed numeric targets, TMDLs WLAs and LAs will require the implementation of such measures. However, the adverse effects of erosion/sedimentation and the loss of lake capacity may continue to be observed over the long-term, unless the sediment is removed. As described in Section 2, these include adverse effects on recreational, wildlife and municipal uses through habitat and substrate changes, reduced depths, etc. Sediment deposition in the lake increases the extent of shallower areas, contributing to the growth of nuisance macrophytes that in turn exert their own set of adverse impacts on recreational and wildlife uses (see also the Big Bear Lake Nutrient TMDLs staff report). These effects of the loss of lake capacity due to sediment loading and deposition in Big Bear Lake are most pronounced during the spring and summer of dry years, when the level of the lake declines and water levels are shallower. Recreational use of the lake is typically at its peak during these months and this is also the period of macrophyte growth. Similarly, the longer-term effects of changes in substrate in Rathbun Creek due to erosion and sediment deposition are likely to be

more pronounced during dry periods, when flows in the creek are low, and repopulation of the benthic macroinvertebrate community may be problematic. The proposed TMDLs account for the dry period critical conditions by specifying alternative numeric targets, including a lake capacity target for Big Bear Lake and benthic macroinvertebrate metrics for Rathbun Creek. In addition, the proposed implementation plan includes a requirement for the development of a lake management plan that is to identify an overall sediment control and management strategy designed to restore and protect beneficial uses, including during the critical dry periods.

## 8.0 MARGIN OF SAFETY

TMDLs must include an explicit or implicit margin of safety (MOS) to account for uncertainty in determining the relationship between pollutant loads and impacts on water quality standards. An explicit MOS can be provided by reserving (not allocating) part of the TMDL and therefore requiring greater load reductions from existing and/or future sources. An implicit MOS can be provided by conservative assumptions in the TMDL analysis. The assumptions that account for the MOS should be adequately identified.

Sources of uncertainty in the Big Bear Lake sediment TMDL development analysis include: 1) the lack of watershed specific data on sediment loading from surface runoff to allow calibration of the water quality component of the watershed model; 2) the lack of discharge measurements from the tributaries; 3) the inherent seasonal and annual variability in delivery of sediment; 3) the lack of data to verify assumptions made about the efficiency of potential BMPs; 4) the absence of a high elevation weather station for use in calibrating the watershed model; 5) the lack of both bedload and suspended sediment concentration data; 6) the lack of information regarding rates, types and locations of erosion in the watershed; 7) the lack of suspended sediment concentration data taken over the hydrograph; 8) the assumption that the Rathbun Creek sedimentation basins are representative of sediment loading within the watershed and that the quantified amount reflected all of the sediment loads from the tributary; and, 9) the lack of knowledge of delivery of sediment from baseflow, storm event and snowmelt runoff. In addition, the lake and tributary water column monitoring were carried out during drought years; data for other hydrologic conditions are lacking.

Because of these uncertainties, staff recommends use of an explicit margin of safety. A MOS of 10% is thought to be adequate to represent the uncertainty in sediment loads. As new data are collected under various hydrologic conditions, data gaps will be filled, an uncertainty analysis can be conducted and the MOS and TMDLs can be adjusted as appropriate.

## 9.0 MONITORING PROGRAM RECOMMENDATIONS

Federal regulations require the State to identify measures needed to implement TMDLs in the state water quality management plan (Basin Plan) (40 CFR 130.6). California law requires that Basin Plans have a program of implementation to achieve water quality objectives. The implementation program must include a description of actions necessary to achieve the objectives, a time schedule for these actions, and a description of the surveillance and monitoring activities to determine compliance with the objectives. Staff proposes that the Big Bear Lake and Rathbun Creek sediment TMDLs be adopted as phased TMDLs. Further, given the lack of data with regard to beneficial use impacts to Rathbun Creek from sediment, the proposed implementation plan includes a requirement to address this creek. The TMDL's phased implementation framework provides time to conduct further monitoring and assessment,

including refining the existing watershed model. The results of these studies may provide the analytical basis for modifying the TMDL, WLAs, LAs and/or other elements of the TMDLs.

The proposed Basin Plan amendment, shown in Attachment A, includes an implementation plan and monitoring program designed to implement the TMDLs and evaluate their effectiveness. TMDLs are not standards and do not establish new criteria; they are a mechanism to attain existing standards. An implementation plan ensures that the TMDLs achieve this purpose. Implementation is expected to result in compliance with the proposed sediment numeric targets, TMDLs and allocations for Big Bear Lake and Rathbun Creek and thereby ensure protection of the beneficial uses of these water bodies. The proposed implementation plan includes requirements directed at both point and nonpoint sources. Implementation of the Big Bear Lake and Rathbun Creek sediment TMDLs is the responsibility of the dischargers of sediment including the U.S. Forest Service, Big Bear Mountain Resorts, the City of Big Bear Lake, Caltrans, County of San Bernardino, and the San Bernardino County Flood Control District. The Big Bear Municipal Water District must be a cooperating partner working with the local stakeholders to implement the Big Bear Lake sediment TMDL, given the District's significant responsibilities for management of the lake (Section 1.0).

Regional Board staff will coordinate implementation of the TMDLs with the Board's permitting, enforcement and stormwater sections of the Board. In addition, implementation will be coordinated with the following:

- The State Board's Nonpoint Source Implementation and Enforcement Policy (NPS Policy)
- The Big Bear Lake TMDL Workgroup coordinated by the Big Bear Municipal Water District (BBMWD)
- The U.S. Forest Service, San Bernardino National Forest (Big Bear Lake Ranger Station) and the existing MAA between the SWRCB and the Forest Service regarding control of nonpoint source pollution from forest activities within California
- The U.S. Army Corps of Engineers and their Feasibility Study within the Big Bear Lake watershed
- The U.S. Fish and Wildlife Service
- California Department of Fish and Game

## 9.1 Implementation Actions by the Regional Board

In order to implement the TMDLs, WLAs and LAs, Board staff proposes that the Regional Board undertake the following actions. Proposed dates for implementation of these actions are specified in the proposed Basin Plan amendment (Attachment A).

1. Establish New Waste Discharge Requirements or Conditional Waivers of WDRs
    a. Review the State Board's new NPS policy and act accordingly with respect to nonpoint sources. This could include drafting new WDRs or conditional waivers of WDRs for the Big Bear Mountain Resorts and ensuring that the MAA and its provisions between the USFS and SWRCB are being met through new WDRs or conditional waivers of WDRs.

2. Revise Existing Waste Discharge Requirements

   The Regional Board shall review and revise, as necessary, the following existing NPDES permit to incorporate the appropriate WLAs, compliance schedules and monitoring program requirements.
   Waste Discharge Requirements for the San Bernardino County Flood Control District, the County of San Bernardino and the City of Big Bear Lake, Areawide Urban Runoff, NPDES No. CAS 618036 (Regional Board Order No. R8-2002-0012).

3. Review/Revise Sediment Related Water Quality Objectives for Big Bear Lake and Rathbun Creek

   The Regional Board shall review, and revise as necessary, the numeric water quality objectives for turbidity and the narrative objectives for suspended solids for Big Bear Lake and Rathbun Creek. The Regional Board shall also examine the appropriateness of establishing biocriteria for Big Bear Lake and Rathbun Creek.

4. Review collected data on beneficial use impairment due to sediment in Rathbun Creek.

5. Utilize new monitoring data and model simulations for revising the sediment TMDL.

## 9.2 Implementation Actions by Other Agencies/Entities

In order to ensure that effective sediment control and management programs are developed and implemented to achieve the numeric targets, TMDLs, WLAs and LAs, staff proposes that the following requirements for the appropriate responsible entity (-ies), as identified in Section 9.0, be incorporated into the Implementation Plan. Proposed dates for implementation of these actions are specified in the proposed Basin Plan amendment (Attachment A).

- Development and implementation of an approved Big Bear Lake management plan. The intent is to develop a coordinated, long-term program for management of the lake and the water quality problems affecting it so as to assure the restoration and protection of the lake's beneficial uses. The management plan is to identify sediment control and management strategies, including dredging or other remedial actions. The plan must include a methodology for measuring changes in the capacity of the lake to enable determination of compliance with the proposed lake capacity numeric target. The plan is to be coordinated and integrated with other control and management strategies designed to address other TMDL requirements, e.g., nutrient reductions and control of macrophyte growth and species composition. It must also integrate the beneficial use survey information required to be developed pursuant to the Regional Board's March 3, 2005, Clean Water Act Section 401 Water Quality Standards Certification for the Big Bear Municipal Water District's Big Bear Lake Nutrient/Sediment Remediation Project.

- Development and implementation by the responsible parties of an approved plan to address erosion, sedimentation and channel stability problems in Rathbun Creek.

- Development of an IBI for Rathbun Creek by the responsible parties based on benthic macroinvertebrates and physical habitat data. Both the Fish and Game's California

Stream Bioassessment Protocol and the USFS' O/E models can be used to assess improvement in ecosystem health (see Section 3.2.3).

The tasks identified above for Rathbun Creek may be incorporated in the lake management plan for Big Bear Lake. Indeed, in order to provide comprehensive and coordinated management of sediment and other water quality problems in Big Bear Lake, it is expected to be necessary to identify in that plan strategies that apply to all the lake's tributary waters (see also Task 10.3).

## 10.0 MONITORING PROGRAM RECOMMENDATIONS

Section 13242 of the California Water Code specifies that Basin Plan implementation plans must contain a description of the monitoring and surveillance to be undertaken to determine compliance with water quality objectives. Several monitoring requirements are proposed as part of the proposed Big Bear Lake and Rathbun Creek sediment TMDLs (Attachment A) in order to evaluate the effectiveness of actions and programs implemented pursuant to the TMDLs. In addition, since the Big Bear Lake and Rathbun Creek TMDLs are phased TMDLs, follow-up monitoring and evaluation is essential to validate and revise the TMDLs as necessary.

### 10.1 Big Bear Lake In-lake Monitoring Program

The Big Bear Municipal Water District and various stakeholders in the watershed, along with Regional Board staff, implemented a Big Bear Lake in-lake monitoring program in 2001. This program, which is currently ongoing, consists of the collection of water quality data along with depth profile measurements at stations in Big Bear Lake on a year-round basis. The purpose of this program is to evaluate changes in lake water quality due to nutrient and sediment input or other environmental factors. This monitoring program has been funded by stakeholders as well as by grants.

Staff proposes in the Basin Plan amendment that watershed stakeholders continue the in-lake monitoring program to assess the response of the lake to the sediment loadings and to determine if the load reductions and other management strategies that may be implemented result in the achievement of numeric targets (as proposed in Section 3.0). The lake monitoring program for nutrients specified in Task 4.2 of the nutrient TMDLs can suffice as the lake monitoring program for sediment.

### 10.2 Watershed-wide Sediment Water Quality Monitoring Program

A watershed-wide sediment monitoring program was implemented in 2001 by the Big Bear Municipal Water District and various stakeholders in the watershed along with Regional Board staff and is currently ongoing. The purpose of this monitoring program has been to collect data needed to develop the nutrient and sediment TMDLs, as well as other TMDLs. The monitoring program consists of the collection of stream flow and water quality data in the Big Bear Lake watershed. Because there are no USGS stream gages in this watershed, this program is key to developing accurate loading estimates from the watershed and accurate inflow measurements. This watershed-wide monitoring program has been instrumental in the development of the proposed sediment TMDLs and is critical to the implementation plan.

The proposed Basin Plan amendment specifies that the responsible parties continue to implement this watershed-wide sediment monitoring program and focus on collecting sediment yield data from specific land use sources, e.g., open space/forest lands, urban runoff as well as determine and quantify the loads from major erosional processes (e.g., mass wasting estimates, rill erosion, etc.). In addition, suspended sediment and bedload samples should be collected across stream cross-sections. The locally-built weirs and ISCO stormwater samplers, or other flow measuring and sampling devices, should also be continually operated and maintained, and water quality samples should be collected from all stations to quantify sediment loads from various sources in the watershed. In addition, a high elevation weather station should be installed and maintained in order to obtain the necessary data for calibration of the present watershed model. The data generated will not only be used to evaluate TMDL compliance, but will also be used to calibrate/update the current watershed model and refine the TMDLs.

### 10.3 Special studies

Finally, staff believes that there is a need to conduct special, sediment-related studies in the watershed. These studies should be undertaken jointly by the responsible parties as identified in Section 9.0.

- Unified Stream assessment: Perform an assessment of the major tributaries in the watershed to locate and evaluate problems pertaining to sediment and erosion and restoration opportunities within the stream corridor using an established stream assessment protocol (see Task 3.1 in Attachment A).

- Establish a reference reach: Development of a reference reach in the Big Bear Lake watershed will help to determine natural background sediment loads, measure changes in the channel stability of Rathbun Creek and determine appropriate biocriteria for assessing sediment-related impacts to the aquatic biota (see Task 3.1 in Attachment A).

- Model update/development: Update/revision of the watershed sediment model developed by Hydmet, Inc. (2004) will be needed in the future as additional data are generated. An updated watershed model could be used to determine BMP effectiveness and to determine TMDL, WLA and LA compliance. The model could also be used as a tool to evaluate potential pollutant trading options. A lake model will likely be needed to evaluate the effects of sediment on the health of the lake ecosystem. A new lake model will be used for future refinement of the proposed TMDLs, WLAs, LAs and numeric targets.

## 11.0 ECONOMIC CONSIDERATIONS

Regional Water Boards are required to adopt TMDLs as basin plan amendments. There are three statutory triggers for consideration of economics in basin planning. These triggers are:

- Adoption of an agricultural water quality control program (Water Code Section 13141). The Regional Board must estimate costs and identify potential financing sources in the Basin Plan before implementing any agricultural water quality control plan.
- Adoption of water quality objectives (Water Code Section 13241). The Regional Board is required to consider a number of factors, including economics, when establishing or revising water quality objectives in the Basin Plan.
- Adoption of a treatment requirement or performance standard. The Regional Board must comply with the California Environmental Quality Act (CEQA) when amending the Basin Plan. CEQA requires that the Board consider the environmental effects of reasonably foreseeable methods of compliance with Basin Plan amendments that establish performance standards or treatment requirements, such as TMDLs. The costs of the methods of compliance must be considered in this analysis.

It should be noted that in each of these three cases, there is no statutory requirement for a formal cost-benefit analysis.

There are no agricultural operations in this watershed, therefore the first statutory trigger does not apply. The adoption of these TMDLs does not constitute the adoption of new or revised water quality objectives, so the second statutory trigger does not apply here. However, compliance with these TMDLs will likely necessitate changes in programs (including educational programs and BMPs) designed to reduce sediment inputs from urban stormwater or other sources, as well as the implementation of remedial activities such as dredging. The proposed TMDLs also require monitoring and other investigations. The costs of these activities must be considered.

The proposed TMDLs include requirements for the development and implementation of a lake management plan, for the development of an IBI for Rathbun Creek and for both routine monitoring and special investigations. The following provides available cost information. It is expected that this information will be supplemented by the responsible parties for consideration by the Regional Board. Again, the proposed TMDLs are phased and include extended compliance schedules. In part, this is to allow for review and refinement of the TMDLs, and the strategies required to implement them, based on new information. As the TMDLs are reviewed and refined in future, and as potential management strategies are identified and developed through the tasks required in the proposed implementation plan, a more accurate assessment of the costs and methods of funding can be made. If and when the TMDLs are revised through the basin planning process, consideration of the economic ramifications will again be a requisite component of the Regional Board's deliberations.

The development of a recommended lake management plan is expected to require approximately $250,000 - $500,000. Board staff is in the process of evaluating/identifying potential grant sources of funding to support this work. A local match may be required. The costs of implementation of the plan will depend on the strategies identified. Again, grants may be

obtained to support implementation of one or more tasks, and Board staff will support such funding requests through the requisite approval process.

Ongoing watershed and lake monitoring will be required to assess the effectiveness of lake and watershed improvement strategies and in determining compliance with the TMDL numeric targets. Funding for these monitoring programs will largely be provided through 2006 through two Proposition 13 Phase III grants awarded to the Big Bear Municipal Water District and the East Valley Resource Conservation District. These grants are also expected to support some of the studies identified in Section 10, which are scheduled to begin in 2005 and 2006.

Table 11-1 shows some of the ongoing costs associated with the TMDLs. Table 11-2 shows costs associated with dredging.

**Table 11-1. Cost estimates for TMDL monitoring**

| Medium | Study type | Cost per sample $ |
|---|---|---|
| Sediment | Sediment traps | 3000 |
| Water | Tributaries | 100 |
| Sediment | Bedload, suspended sediment concentration and grain size analysis | 150 |
| Sediment | Analyze sediment cores for determination of sedimentation rate and geochemical analyses (cost does not include drilling for the cores) | 30,000 for study |

**Table 11-2. Estimated costs of lake management options for Big Bear Lake**

| LAKE MANAGEMENT TECHNIQUE | TREATMENT ASSUMPTIONS | COST RANGE PER ACRE TREATED ($) |
|---|---|---|
| Dredging | Average sediment depth = 2ft | 15,000 to 50,000 |
| | Average sediment depth = 5ft | 25,000 to 80,000 |

Source: Modified from a table provided as a task deliverable for a Proposition 13 grant (Contract # 02-069-258-0 with the BBMWD).

BMPs such as street sweeping, sediment catchment basins, and cleaning out drainage culverts are already being implemented throughout the watershed. Information provided by the BBMWD, the City of Big Bear Lake and Big Bear Mountain Resorts is summarized below in Table 11-3 (Hamilton 2004; Klouzer 2004; Perry 2004). In addition to the BMPs listed, the City of Big Bear Lake and presumably the County of San Bernardino and the San Bernardino County Flood Control District, implement measures in accordance with the NPDES requirements, such as monitoring erosion control measures on construction sites, BMP training sessions, etc. Note that

as shown in Table 11-3, cost information of BMP implementation only includes that which was provided to staff.

By the end of 2007, the amount of money spent in the Big Bear Lake watershed for developing and implementing the Big Bear Lake TMDLs, including both the nutrient and sediment TMDLs, will have reached well over $4 million (Table 11-4). This amount includes grants funded by Proposition 13, Section 319(h) of the Clean Water Act and TMDL funds provided by the State Board. Not included in this amount is the TMDL Task force budget of $90,000 per year or the other funds contributed by the BBMWD, as well as the $100,000 the U.S. Army Corps of Engineers spent on their reconnaissance study and the money now being spent as part of their feasibility study.

**Table 11-3. BMPs in place within the Big Bear Lake watershed**

| Agency | BMP | Capital Cost | O and M Cost | Date Completed |
|---|---|---|---|---|
| BBMWD | Sediment catchment basins of Rathbun Creek between Elm St. and Moonridge Rd.[1] | | | 1980s |
| BBMWD | 3,000 cubic yard catchment basin at the mouth of Rathbun Creek | | $37,912 cleaned out in 1998 | Early 1990s |
| BBMWD | 9,000 cubic yard catchment basin on lake bottom at the mouth of Rathbun Creek | $9,000 | | 2000 |
| BBMWD | Stabilized channel banks of Sand Canyon Channel in the area of Sheephorn Road[2] | $32,200* | | October 1997 |
| BBMWD | Replaced two storm culverts and a portion of Teton Road and bank stabilization work in the Sand Canyon Channel[2] | $185,000** | | April 2002 |
| BBMWD | Bank stabilization project below the box culvert near the confluence of Summit and Rathbun Creeks.[3] | $15,500 | | 2000 |
| BBMWD | Shoreline erosion control[4] | | | Ongoing |
| City of BBL | Street sweeper[5] | $141,236.30 | | Purchased 1999 |
| City of BBL | Sweep 658 curb miles of roadway-removal of 1,000 cubic yards of debris and snow cinders | | Contracted out by City | Ongoing |
| City of BBL | Testing and disposal of cinders and debris in accordance with State and Federal regulations | | $20,000 annually | Ongoing |
| City of BBL | Dept. of Public Works inspects and cleans as necessary, 135 drainage culverts annually | | 2003-160 hours hydro-vactoring 80 culverts | Ongoing |
| Big Bear Mountain Resorts | Soil protection measures, cross ditching, overside drains, culverts, silt collection dams and basins, runoff filtering, temporary measures | | | Ongoing |

[1]The basins are cleaned out annually by Bear Mountain ski resort.
[2]The San Bernardino County Flood Control District, the City of Big Bear Lake, the BBMWD and the East Valley Resource Conservation District were involved in two 319(h) projects pertaining to channel erosion control in the Sand Canyon channel.
*Overall cost of project was $278,771, the BBMWD's share was $32,200.
**Overall cost of project was $377,849, the BBMWD's share was approximately $185,000.
[3]Culvert was cleaned out by Snow Summit ski area –prior to project, culvert capacity was reduced by more than 50%.
[4]The BBMWD has prepared a pamphlet explaining methods of shoreline erosion control.
[5]The City of BBL utilizes the street sweeper to sweep the four-lane portion of Big Bear Blvd. (approx. 2.5 lineal miles) a minimum of 26 times per year.

**Table 11-4. Sources and amounts of funding for the Big Bear Lake Watershed**

| Funding Source | Project | Deliverables | Amount | Recipient |
|---|---|---|---|---|
| State TMDL funds | Nutrient monitoring | Watershed and lake nutrient monitoring from June 01-Oct.02 | $40,000 | BBMWD |
| State TMDL funds | Nutrient Budget | HSPF model<br>WASP model<br>Sediment core-flux analyses and sediment characterization<br>Watershed and lake nutrient monitoring<br>ISCO samplers<br>Plant tissue analyses | $77,000 | BBMWD |
| Prop. 13 | Pilot-scale remediation | Lake wide fish survey<br>Lake wide macroinvertebrate study<br>Biological surveys (zooplankton, phytoplankton)<br>Access database of all monitoring data<br>Trial alum project in Papoose Bay<br>Big Bear Lake Atlas website | $200,000 | BBMWD |
| Federal 319(h) funds | Nutrient and plant remediation | Sonar application<br>Pre-and post- treatment aquatic macrophyte surveys | $120,000 | BBMWD |
| Prop. 13 | High resolution aerial mapping | Low and high altitude aerial photography<br>GIS coverages (DTM, contours, utility, parcels) | $490,000 | SBC |
| Prop. 13 | Large-scale alum application | Lake wide alum application<br>Water quality monitoring prior to, during and after project<br>Sediment core-flux data | $500,000 | BBMWD |
| Prop. 13 | Lake and Tributary monitoring support | Continued water quality monitoring-2005<br>Phytoplankton and zooplankton analyses<br>Preliminary macrophyte index | $80,000 | BBMWD |
| Prop. 13 | BMP implementation | BMP implementation in Snow Forest area<br>NPS education | $250,208 | EVRCD |
| Federal 106(g) funds | WASP model | WASP model<br>Updated HSPF model runs | $50,000 | RWQCB8 |
| Prop. 13 | Lake dredging and study | Continued water quality monitoring<br>Studies needed for TMDL implementation<br>High elevation weather station<br>Monumented cross-sections<br>Dredging of east end<br>Update to Access database<br>Model plan | $2,300,000 | BBMWD |

# 12.0 CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

The Secretary of Resources has certified the Basin Planning process as "functionally equivalent to" the preparation of an Environmental Impact Report (EIR) or a Negative Declaration pursuant to the California Environmental Quality Act (CEQA). However, in lieu of these documents, the Regional Board is required to prepare the following: the Basin Plan amendment; an Environmental Checklist that identifies potentially significant adverse environmental impacts of the Basin Plan amendment; and, a staff report that describes the proposed amendment, reasonable alternatives, and mitigation measures to minimize any significant adverse environmental impacts identified in the CEQA checklist. The Basin Plan amendment, Environmental Checklist, and staff report together are functionally equivalent to an EIR or Negative Declaration.

The draft Environmental Checklist (Attachment B to this report) concludes that there would be no potentially significant impacts on the environment caused by adoption of this Basin Plan amendment. Therefore, no mitigation measures are required.

This staff report will be followed by another report that includes comments received on the proposed amendment, staff responses to those comments, and a discussion of any changes made to the proposed amendment as the result of the comments or further deliberation by the Board, and/or Board staff. This follow-up report would address any additional CEQA considerations, including economics, that might arise as the result of any changes to the proposed amendment.

**Consideration of Alternatives**

1. No Project Alternative

The "No Project" alternative would be no action by the Regional Board to adopt a TMDL with implementation measures and a monitoring program. This alternative would not meet the purpose of the proposed action, which is to correct ongoing violations of the Basin Plan narrative objectives regarding suspended solids and adverse impacts to beneficial uses. This alternative would result in continuing water quality standards violations and threats to public health and safety and the local economy. This alternative would not comply with the requirements of the Clean Water Act.

2. Alternatives

The Regional Board could consider TMDLs based on alternative numeric targets, such as more restrictive numeric targets; however, the proposed numeric targets are based on the best scientific information now available concerning sediment and its impact to Big Bear Lake and Rathbun Creek. The proposed targets provide the best assurance that the narrative water quality objective for suspended solids will be achieved and that the beneficial uses of both water bodies will be protected.

The Board could also consider an alternative TMDL implementation strategy that is based on a different compliance schedule approach. Adoption of a longer schedule would prolong non-attainment of the water quality standards. The proposed compliance schedule approach reflects the timing of implementation of projects that have been carried out and that are proposed for Big Bear Lake. These projects are expected to result in improvements in lake water quality. The proposed compliance schedule also considers the need for additional studies to fill data gaps, particularly the collection of data during wet hydrological conditions, and to address uncertainties in the TMDL calculations. The proposed compliance schedules are therefore considered reasonable.

3. Proposed Alternative

Staff believes that the recommended TMDLs reflect a reasoned and reasonable approach to the improvement of beneficial uses of Big Bear Lake and Rathbun Creek. The proposed implementation schedule also provides a realistic time frame in which to complete the tasks required by the TMDL.

## 13.0 PUBLIC PARTICIPATION

Federal TMDL regulations require public participation to provide the public an opportunity to review and comment on the TMDLs. A number of opportunities for public participation are afforded throughout the entire TMDL Basin Plan Amendment process and through the CEQA review process.

- Basin Plan amendments require advanced public notice and a public hearing (CWC § 13244).
- CEQA requires circulation of a Notice of Filing to the public and interested public agencies.
- Public workshops are held by the Regional Board to consider evidence and testimony related to the proposed TMDLs.
- Regional Board staff must prepare written responses to comments that are received at least 15 days before the Board's public hearing. For those late comments for which written responses are infeasible and for oral comments at the Board meeting, staff must respond orally at the public hearing.
- Draft TMDLs, Basin Plan Amendments, Public Notices, Notice of Filing, CEQA documentation are made available on the Regional Board's website.
- After Regional Board adoption of the Basin Plan Amendment, the SWRCB and the USEPA conduct their review and approval processes, which afford more opportunities for public participation.
- Documentation of all public participation, including copies of hearing notices, press releases, written public comments and written responses, and tapes or minutes of hearing testimony will be included in the administrative record of the Basin Plan amendments.

In June 2000, Regional Board staff convened a TMDL workgroup to assist staff in the development of the Big Bear Lake and Rathbun Creek sediment TMDLs. Soon thereafter the Big Bear Municipal Water District hired Tim Moore of Risk Sciences as the TMDL facilitator. The BBMWD created the Big Bear Lake TMDL Task Force, which includes representatives from the Big Bear Municipal Water District, San Bernardino County Flood Control District, City of Big Bear Lake, the Big Bear Area Regional Wastewater Authority, Caltrans, the Big Bear City Community Services District and the Big Bear Mountain Resorts, and just recently, the USFS. The BBMWD also created a TMDL fund to pay for studies in the watershed with contributions by the BBMWD, the City of Big Bear Lake, the San Bernardino County Flood Control District and the Big Bear Area Regional Wastewater Authority. The Big Bear Municipal Water District has been instrumental in assisting Regional Board staff in the development of the proposed sediment TMDLs by compiling existing data, designing, coordinating and implementing the watershed and in-lake monitoring programs, and reviewing the results of studies conducted in the watershed. The District has also secured a number of grant funds, including a Clean Water Act Section 319(h) grant that was used to eradicate the Eurasian watermilfoil, a noxious aquatic plant, from Big Bear Lake and several Proposition 13 grants (see Table 11-4). The Proposition 13 funds have supported a macroinvertebrate study, a pilot alum project along with a full-scale alum

project, lake and tributary monitoring, to name just a few items. In addition, the County of San Bernardino along with the City of Big Bear Lake was awarded a Proposition 13 grant to obtain aerial photos of the entire Big Bear Lake watershed for implementation of their stormwater program and for other projects within the watershed. The East Valley Resource Conservation District was also awarded a Proposition 13 grant to work with the USFS in reducing sediment and nutrient loads from an abandoned ski area in the watershed. As previously indicated, by the end of 2007, more than 4 million dollars will have been spent by the state and EPA to develop and implement TMDLs within this watershed (Table 11-4).

## 14.0 STAFF RECOMMENDATION

Direct staff to prepare a Basin Plan amendment and related documentation to incorporate the TMDLs for sediment for Big Bear Lake and Rathbun Creek that are shown in Attachment A for consideration at a future public hearing.

## 15.0 REFERENCES

Bear Mountain Resort. 2003. Bear Mountain mountain facts, September 9, 2003, http://www.bearmtn.com/bm_mtnfacts.php (December 29, 2004).

Beschta, Robert L. 1996. Suspended sediment and bedload. In *Methods in stream ecology*, eds. F.R. Hauer and G.A. Lamberti, 123-143. San Diego: Academic Press.

Bicknell, Brian R., J.C. Imhoff, J.L. Kittle, Jr., T.H. Jobes, and A.S. Donigan, Jr. 2001. *HSPF version 12 user's manual*. March. Mountain View, CA.

Big Bear Municipal Water District (BBMWD). 2002. *Big Bear Municipal Water District management plan*. Big Bear Lake, CA.

———. 2004a. Big Bear watermaster data (1977-2002) and lake level data (2003-2004). Big Bear Municipal Water District. [File *watermaster_elevation.xls* dated May 3, 2005]

———. 2004b. *Precipitation measurements taken at Dam from 1884-2004*, n.d., http://www.bbmwd.org/PDF/18842004precipmonthlydata.pdf (May 24, 2004). [File *18842004precipmonthly.pdf* dated May 24, 2004].

Big Bear Municipal Water District (BBMWD), Hydmet, Inc., and AquAeTer, Inc. 2003. *Nutrient budget study for Big Bear Lake*. Prepared for the Santa Ana Regional Water Quality Control Board. June. Big Bear Lake, CA.

Big Bear Watermaster. 2001. *Twenty-fifth annual report for calendar year 2001*. Redlands, CA.

Black and Veatch. 1990. *Preliminary feasibility study for wastewater reuse for the Department of Water and Power, City of Big Bear Lake*. April. Irvine, CA.

City of Big Bear Lake. 1999. *General plan*. Big Bear Lake, CA.

Cohn, Barry R. and James G. Retelas. n.d. *Soil survey of San Bernardino National Forest Area, California*: United States Department of Agriculture, Forest Service.

Courtier, Michelle and Hope Smythe. 1994. *Investigation of toxics and nutrients in Big Bear Lake*. Riverside, CA: Santa Ana Regional Water Quality Control Board.

Crandall, LeRoy and Associates. 1978. *Hydrogeologic studies, Big Bear Lake-Baldwin Lake area, San Bernardino County, California*. May. Los Angeles, CA.

Engineering Resources of Southern California, Inc. 1998. *Big Bear Area Regional Wastewater Agency proposed recycled water project "A View to the Future"*. 4 November. San Bernardino, CA.

Gray and Glysson. 2000. Are total suspended solids and suspended sediment concentrations in open-channel flows the same data type? *Proceedings of the 7th International Conference on Fluvial Sedimentology*. 6-10 August. Lincoln, NE.

Guy, Harold P. 1970. Fluvial sediment concepts. Book 3, Chapter C1, *Techniques of water resources investigations of the United States Geological Survey*. Arlington, VA.

Hamilton, Sheila, General Manager, Big Bear Municipal Water District. 2004. Letter from Big Bear Lake to Hope Smythe, Chief of the Inland Waters Planning Section, Santa Ana Regional Water Quality Control Board, 5 February.

Hawkins, Charles P. n.d. *Summary of initial development and testing of a RIVPACS-type model for assessing the biological condition of streams in Region 5 USDA Forest Service*. Draft document. Logan, UT: Utah State University.

Helsel, D.R. and T.A. Cohn. 1988. Estimation of descriptive statistics for multiply censored water quality data. *Water Resources Research* 24: 1997-2004.

Humphrey, John (Jack), HSPF modeler, Hydmet, Inc. 2003a. Email correspondence with Erika Saad, 17 April.

———. 2003b. Personal communication, 7 July.

Hydmet, Inc. 2004. HSPF data including nutrients, sediment, and land use. [File *bigbearsedimentandwaterquality.xls* dated June 17, 2004].

Irwin, G.A, and M. Lemons. 1974. *A water quality reconnaissance of Big Bear Lake, San Bernardino county, California, 1972-73.* Report No. 276-01, Menlo Park, CA: United States Geological Survey, Water Resources Investigation.

Kirby, Matthew. 2005. *Determination of sedimentation rate and sedimentation processes at Big Bear Lake: Using a paleo-perspective to understand modern sedimentary systems.* Final contract report prepared for the Big Bear Municipal Water District. Fullerton, CA: California State University, Fullerton.

Klouzer, Karl, Mountain Manager, Big Bear Mountain Resorts. 2004. Letter from Big Bear Lake to Hope Smythe, Chief of the Inland Waters Planning Section, Santa Ana Regional Water Quality Control Board, 12 May.

Leidy, Roy. 2003. *Prehistoric and historic environmental conditions in Bear Valley, San Bernardino County, California.* Draft report prepared for Risk Sciences. Sacramento, CA: EIP Associates.

Leopold, Luna, M.G. Wolman, and J.P. Miller. 1995. *Fluvial processes in geomorphology*. San Francisco: W.H. Freeman and Company, 1964. Reprint, New York: Dover Publications (page references are to the reprint edition).

Martin, Gene, Lake Manager, Big Bear Municipal Water District. 2003. E-mail correspondence with author, 30 Jan. Riverside, CA.

Mount, Jeffrey F. 1995. *California rivers and streams*. Berkeley: University of California Press.

Neste, N.A., J.R. Brudin, and R.V. Stone. 1973. *Final report draft: Big Bear area regional wastewater management plan*. San Bernardino, CA.

Novotny, Vladimir and Harvey Olem. 1994. *Water quality: Prevention, identification, and management of diffuse pollution*. New York: Van Nostrand Reinhold.

Ode, Peter R., Andrew C. Rehn, and Jason T. May. 2004. A benthic macroinvertebrate index of biotic integrity for Southern Coastal California.

Owen, Don and Associates. 1977. Final baseline environmental impact report for lake restoration activities, volume I. Irvine, CA.

Perry, Michael, City Manager, City of Big Bear Lake. 2004. Letter from Big Bear Lake to Hope Smythe, Chief of the Inland Waters Planning Section, Santa Ana Regional Water Quality Control Board, 27 February.

RBF Consulting. 2003. *BMP effectiveness and applicability for Orange County*, Appendix E1, Prepared for the Orange County stormwater program as part of the Drainage Area Management Plan (DAMP). Irvine, CA.

Reid, Leslie M. and Thomas Dunne. 1996. *Rapid evaluation of sediment budgets*. Reiskirchen: Catena Verlag Gmbh.

San Bernardino County Flood Control District. 1998. *San Bernardino County stormwater program annual report: Reporting year July 1997 to June 1998.* San Bernardino, CA.

Santa Ana Regional Water Quality Control Board. 1995. *Water quality control plan: Santa Ana River basin (8)*. Riverside, CA.

Siegfried, C.A., P.L. Herrgesell, A.P. Pickard, and W.E. Loudermilk. 1978. *Limnology of Big Bear Lake in 1977, a drought year.* Technical Report. No. 78-1. Big Bear Lake, CA: California Department of Fish and Game, Big Bear Lake limnological laboratory.

Thomas 1985. *Measuring suspended sediment in small mountain streams*. Gen. Tech. Rep. PSW-83, Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, United States Department of Agriculture.

United States Department of Agriculutre, Forest Service (USFS). 2000. *Water quality management for forest system lands in California: Best management practices*. Vallejo, CA.

United States Department of Agriculture, NRCS (USDA). 1995. *Rathbun Creek watershed restoration project: Preliminary design plan*. San Bernardino County, CA.

United States Environmental Protection Agency (USEPA). 1999a. *Protocol for developing nutrient TMDLs*. EPA 841-B-99-007. Washington, D.C.: Office of Water, USEPA.

———. 1999b. *Protocol for developing sediment TMDLs*. EPA 841-B-99-004. Washington, D.C.: Office of Water, USEPA.

———. 2000. *Nutrient criteria technical guidance manual: Rivers and Streams*. EPA 822-B-00-002. Washington, D.C.: Office of Water, USEPA.

Uplinger, Richard. Mojave Hatchery. 2000. Telephone interview

Walker, W. W. 1996. Simplified procedures for eutrophication assessment and prediction: User manual, Instruction Report W-96-2 (Updated April 1999). Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station.

Wetzel, Robert G. 2001. *Limnology: Lake and river ecosystems*. 3d edition. San Diego: Academic Press.

# ATTACHMENT A

**Resolution No.**

To be submitted at a later date